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GENERATION AND PHYSICAL CHARACTERIZATION OF HOUSEHOLD WASTE IN ANNABA CITY

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Abstract

This study is a physical characterization of household waste in the town of Annaba (Algeria North East). Based on an adequate sampling protocol that takes into account the constraints of Algerian cities; Annaba city was taken as a case study for the rapprochement of the situation in Algeria. A quantity of 90 to 120 kg was sorted for each type of habitat in the city during four seasons of the year 2010 to 2011 according to 11 components of household wastes. Variations in the percentages of some components depending on the seasons and the type of habitat were recorded, especially the organic matter, the plastic, the glasses, and metals. Also; the weighing of the samples showed the variation of the production ratio per capita according to the season and the type of habitat. However, the largest production ratio was recorded for the height standing and the small one for low standing.

Key words: household solid waste, waste composition, waste generation, waste management

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1. Introduction

Nowadays, the most important source of environmental deterioration in Algeria is created by the poor refuse disposal facilities (Schiopu and Gavrilescu, 2010). Even more, inadequate management of solid waste in the majority of the developing countries cities is at the head of problems which affects the human and animal health and has heavy consequences resulting in economic, environmental and biological losses.

Nevertheless, today urban solid waste can constitute the raw material for various economic, agricultural, artisanal or industrial activities. In Algeria, the 01-19 law adopted on 12 December 2001 has set the terms of the management, control and waste treatment, based on the principles of the prevention and the reduction of the waste toxicity production at the source as well as the recovery of waste by re-use, recycling or any other action to obtain from the waste, reusable materials or energy; unfortunately, this aspect of waste management; remained a long time been unaware of by the urban managers worried rather by the collection and the evacuation of waste. It is the informal sectors which support the activities of recovery, recycling and transformation of waste. In Algeria the average quantity of the generated household waste is estimated at 0.5 g/inh/d, certain authors admit a rate between 0.6 to 0.7 kg/inh/d (AND, 2014) in the big urban centers. The Ministry of town and country planning showed the possibility to recover 760.000 t/ year; including 385.000 paper t/year; 130.000 plastic t/year; 100.000 metal t/year; 50.000 glass t/year and 95.000 various matter t/year. The valorisation of this waste quantity corresponds to 43.99 million dollars' profit (Cheniti, 2014). It is a segment of investment to be developed in all the municipalities and particularly those justifying a

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significant reserve.

Annaba city is the fourth big city after Algiers, Oran and Constantine, it is located between the latitude of 7° and 42°, and longitude of 36° and 53°, in the North East of Algeria at 100 km from the Algerian-Tunisian border in the East, and at 580 km from the capital Algiers in the West, with 657.756 inhabitants (GPRH, 2008); Annaba city, as all Algerian urban centre's, generates a plethora of problems, among which that of household waste posed with acuity.

The landfill of Annaba city (Berka Zerga) is one of the many uncontrolled discharges in Algeria. It receives about 500 tons/day of both urban and industrial solid waste; directly stocked on the floor. It is located at 15 km west of Annaba city in a very vulnerable environment (near the Fetzara Lake, the presence of a dense urban network, and intense agricultural activities) (Djorfi et al., 2010). The surface waters and the leachate flows from the discharge pour into the Zied River, which pours into the Fetzara Lake, which is classified as protected ecosystem since 2006 by the Ramsar Convention (Djorfi et al., 2010). Else, the aim of the household waste characterization study, as indicated by several authors, is to provide the maximum of information and data helping the decision-makers to predict the future waste management styles (valorisation, recycling, treatment); which helps to solve the pollution problems resulting of waste (Morvan, 2000). For that, our study will bring an answer about the composition and the rate of household waste generation in the city.

2. Material and methods

2.1. Sampling methodology

Sampling is the decisive stage of the waste characterization studies, where a certain number of parameters must be fixed; such as the stratification of the city districts and the weight of samples to be taken in each district. Two approaches are generally applied for the waste physical characterization, the first supports to the sample selection from the container or the sites of transit as the study of, and the second approach supports sampling at the source from the households, and this help to obtain detailed results concerning the waste composition (SENES Consultants Limited, 1999). This is why we have chosen this second approach for the collection of our samples.

2.1.1. Weight of the sample waste to sorting

The studies of household waste characterization propose various masses of sample (Table 1). The mass of the sample depends on several factors of economic order, convenience and/or according to the objective. Four our case, the weight of the household waste to be sorting was determined by the time factor; since the samples must be collected in the same conditions at the household, so it is expected that the waste collected for two days are sorted the third day for each habitat type (Table 3 section 2.1.3), and due to the impossibility of working at night; it was necessary that the samples will be sorted through a day's work, based on these constraints we consider that a day's work does not allow us to sort more than 90 to 120 kg of waste.

To determine the number of households producing this quantity of waste sample, a pre-indicative survey was conducted in the city of Annaba for 2 days; this was done randomly by choosing six districts, each one for a habitat type, and the daily weighing of their household waste produced. Indicative results showed a variation of waste households' production about 1.6 to 3.6 kg, with an average production of 2.6 kg per household per day, so the number of households producing the desired quantity required is 35 to 40 households.

2.1.2. Stratification of the districts in the city

Household waste is a heterogeneous mixture of products with very different physicochemical properties. Its composition is variable and depends on the nature of the products, customs of the population, the living level and the type of city (Guermoud et al., 2009).

The physical characterization studies at the source in the cities of developing countries as the work of Alouimine (Alouimine, 2006) are very few. This author has made a stratification by three strata according to the standard of living (the height, middle and low standard), but these strata are not distinguishable usually from each other in Algerian cities, where the need to think about relevant criterion standard of living. Kobiane works in the city of Ouagadougou (Kobiane, 2004) provides an explicit answer to this question when he proposed an indicator of standard of living based on the characteristics of the habitat.

This author has taken nine habitat features distinguishing each habitat type of other (kind of ripe, floor materials, a toilet, a source of energy for cooking, source of energy for lighting, number of rooms, housing mode of water supply, shower type and waste disposal mode). One of the conclusions is that this indicator of level living is mainly used to distinguish the extreme classes (the very rich and the very poor).

Table 1. Weights to be sampled proposed in the literature

Sampling procedure at the source		***Sampling procedure at the container***	
Weight to sorting	***Author***	***Weight to sorting***	***Author***
100 kg	EC, (2004)	100 to 200 kg	Mohee (2002)
		200 to 300 kg	Kathiravale et al. (2003)
		320 kg	Ben Ammar (2006)
150 kg	Diop (1988)	500 kg	Morvan (2000)
		500 kg	ADEME (1993)

Furthermore; in Algeria, the existing indicators of life level (health, education) are global, it does not go down into the households; which is our unit of measurement and sampling, moreover; much of the housing in Algeria consists of social housing subdivision; (land for the construction of social dwellings whose characteristics are defined by the law), it does not exceed 65 m^2 for housing and 150 m^2 for the subdivision; beyond these dimensions, we have another class of housing (the promotional) in the law of the land market. These housings are distributed by the state; it retains the income level as a criterion for distribution. It sets income level thresholds for getting access to the social housing estate, also; these thresholds, in turn, depend on market development; therefore, the social or promotional habitat indicates the income level hierarchy and automatically indicates the living level.

These indicators could show us three classes of level living: The height standing include districts where all the characteristics of modern living are available with a modern system of waste collection (individual garbage container for individual promotional houses and collective garbage for the collective promotional houses), while the middle standing includes less rich districts built during the colonial period and those built by the state for a slice of the population that does not exceed a certain level of salary (collective social houses and individual colonial houses). Concerning the low standard of level living, it includes the illicit and the old city houses (illicit habitat and old city); these houses do not usually have a network for drinking water or energy for cooking and do not have a permanent waste collection mode.

It is for that and in order to reduce at the same time the variability of the generation rate and the composition of waste, the districts of the city were stratified according to the type of habitat. The town of Annaba was cut out according to the following habitat types: promotional individual habitat (P.I.H) and the promotional collective habitat (P.C.H) for the height level living, social collective habitat (S.C.H) and the colonial individual habitat (C.I.H) for the middle-level living, illicit habitat (I.H) and old city habitat (O.C.H) for the low-level living. This classification covers completely the city of Annaba (see Fig.1). Finally, stratified random sampling was conducted for the selection of sampling districts (Table 2).

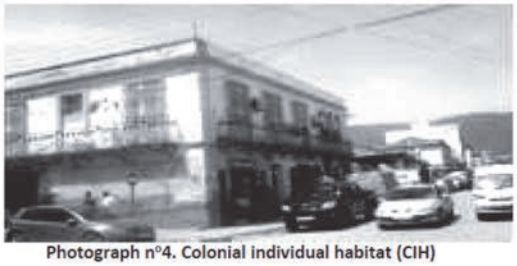
2.1.3. Collection of samples

Once the sampling terms were set, the implementation of the household waste sample collection device proceeded; the two first days (d1, d2) of the weeks was devoted to the distribution of the plastic bags and the recovery and sorting are carried out the third and the fourth days (d3, d4) of each week. A one-day lag between the different districts was applied (Table 3).

Photograph n°1. Promotional individual habitat (PIH)

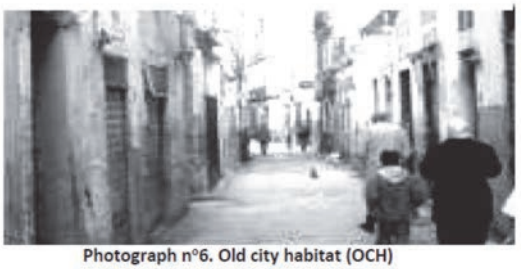
Photograph n°2. Promotional collective habitat (PCH)

Photograph n°3. Social collective habitat (SCH)



Photograph n°4. Colonial individual habitat (CIH)

Photograph n°5. Illicit habitat (shanty town) (ICH)



Photograph n°6. Old city habitat (OCH)

Fig.1. Photographs of existing habitat type in Algerian cities (Cheniti et al., 2013)

Each sample will be weighed every season, and its contents classified according to the following categories: Organic matters, Paper and paperboard, Plastics, Rags and textiles, Fines (<20mm), Composites, Combustibles not classified (C.N.C), Incombustible not classified (I.N.C), Metals, Glass and Special waste. Afterward, the information obtained from the sample was processed; a database was designed to facilitate processing.

Table 2. Results of the survey carried out in the city for 4 seasons

Habitat type / *Seasons*		*The high level*		*The middle level*		*The low level*	
		P.I.H	***P.C.H***	***C.I.H***	***S.C.H***	***I.H***	***O.C.H***
Spring	districts	Beau séjour	ADL bouledroum city	Bouzrade houssin	1028 residences city	Sidi harbe1	Old city
Summer		Menadia	Sidi achour city	Elysa city	240 residences city	Sidi harbe2	Old city
Autumn		Elfakharine	Sidi achour city	La caroube	11 December 60 city	Sidi harbe2	Old city
Winters		Sidi Aissa	The Mediterranean city	Town center	1772 residence city	Sidi harbe1	Old city

Table 3. Chronogram of sample collection and sorting

	H.V.V	***H.I.P***	***H.C.P***	***H.I.P***	***H.I***	***H.C.S***
Plastic bags distribution (days)	d1	d2	d5	d6	d9	d10
Collect and sorts (days)	d3	d4	d7	d8	d11	d12

3. Results and discussion

3.1. Waste generation

Several authors attest an undeniable bond between the waste generation and the socioeconomic level (Medina, 1997; Bandara et al., 2007). This bond is also confirmed in our case. Indeed, the results of the weighing (Table 4) reveal that household waste generation varies in quantity and quality according to two independent factors: the type of habitat and the season.

The first factor shows that the resident of the promotional collective or the promotional individual habitat generates more waste daily with 0.52-0.56 kg, which is more than the resident of the colonial individual or social collective habitat with 0.47 kg. Moreover, the smallest quantities are recorded in the old city and the illicit habitat with only 0.41-0.43 kg.

The second factor confirms the season effect on the waste generation rate, where the highest rate of generation was noticed during summer (Table 4) in the promotional individual habitat, while the lowest rate was noticed in the old city habitat. The average of waste generation per inhabitant in the city is close to that estimated in Biskra and Mostaganem and far from that of the country, and that is explained by made that the national average generation of waste in the developing countries (Table 5) are very often based on non-exhaustive population censuses, and the summary evaluation of the quantity and quality of collected waste (Anie, 2010), to that are added the almost total absence of the equipment of weighed in the discharges generally not controlled.

3.2. Physical composition of household waste in Annaba

The observation of the results in Figs. 2-5 proves that the flow of waste in the city is a mixture of products and materials whose composition varies from a habitat type to another. Also, the components of this household waste flow break up into two groups according to the percentage by wet weight.

The first group contains the main components in percentage where the domination of the organic part can be easily noticed with 45.72%, as in Mostaganem case where it is of 64.6% (Guermoud et al., 2009) and the case of the Maghreb countries: Libya 42-48%, Marocco 50-70%, Tunisia 37-81% (Ben Ammar, 2006). The high consumption of the fruit and vegetables by the inhabitants (a common characteristic of the developing countries), could explain the magnitude of the organic matter in the household waste.

The fraction of rag and textile comes in the second position with 15.04%; which is extremely important unlike Algerian cases and could be explained by the fact that this categories of waste contain both of textiles, medical textiles and rags, also; this result is noticed due to the sampling method used (at the source) in the case of Nouakchott; where the sum of these three textile components is of 17% for the high standing and 8.1% for the low standing (Aloueimine, 2006). After that comes the fraction of fines (12.36%).

In the fourth position we find the fraction of plastic with 10.01% similarly to that recorded in many Algerian cities such as Bordj Bourrairidj 9%, Chleff 12% (Mezouari, 2011), Mostaganem 10.5% (Guermoud et al., 2009), and Algiers by 16.45% (Djemaci, 2012), and more than that recorded in the Maghreb countries: by 2% in Libya, 2-8% in Morocco and by 1-16% for Tunisia (Ben Ammar, 2006); this is because the plastic remains the most widespread way of packing drinks and the households' needs, yet; it should be noted that law is under study focuses on the

prohibition of the production and the importation of black plastic bag, and that could reduce significantly the quantities throne of this fraction. Finally comes the fraction of Paper and paperboard by 5.20%, less than that recorded in each of Bordj Bouarrairidj 15.5%, Chlef 4% (Mezouari, 2011), Mostaganem 15.9% (Guermoud et al., 2009) and by13.4% in Algiers (Djemaci, 2012) and close to that recorded in some Maghreb countries: Marocco 5-20%, Tunisia 1-23% (Ben Ammar, 2006).

Table 4. Generation rates of waste per inhabitant by season for each habitat type (in kg)

	P.I.H	***P.C.H***	***S.C.H***	***C.I.H***	***O.C.H***	***I.H***
Spring	0.49	0.47	0.45	0.46	0.36	0.38
Summer	0.68	0.65	0.44	0.54	0.45	0.44
Autumn	0.41	0.43	0.47	0.39	0.48	0.43
Winters	0.67	0.53	0.50	0.47	0.36	0.45
Average	0.56	0.52	0.47	0.47	0.41	0.43
Rate of generation (kg/inh/day)	0.48					

Table 5. Waste production in some cities

Country	***City***	***Production rate (kg/inh/day)***	***References***
Algeria	-	0.8	AND (2014)
	Annaba	0.48	This study
	Mostaganem	0.62	Guermoud et al. (2009)
	Biskra	0.55	Mezouari (2011)
	Algiers	0.75	
Marocco	Casablanca	0.89	Ben Amar, (2006)
Tunisia	Tunisia	0.8	

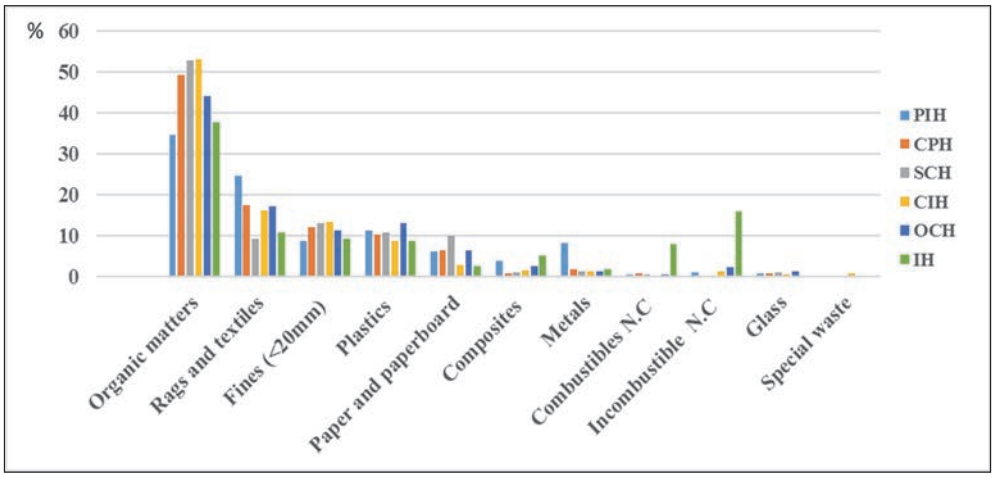


Fig. 2. Variation of the household waste composition by habitat type in spring 2011

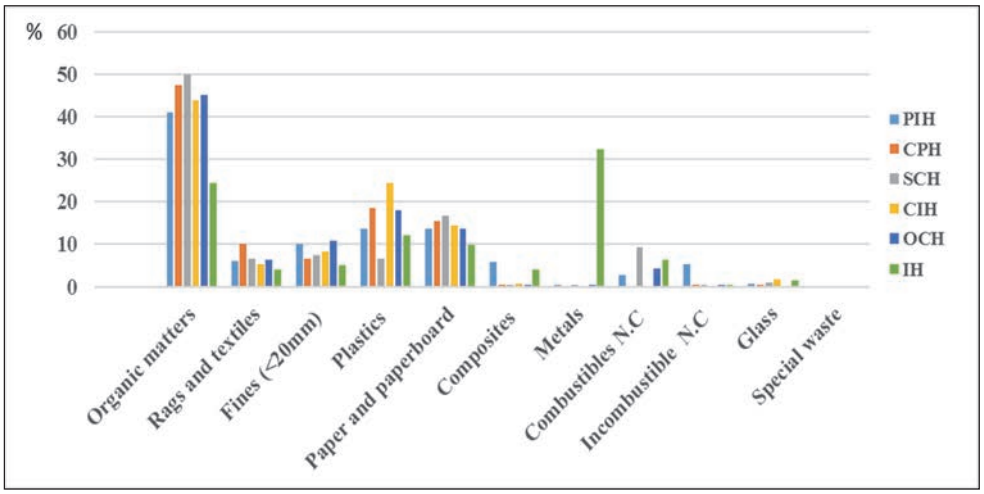


Fig. 3. Variation of the household waste composition by habitat type in summer 2011

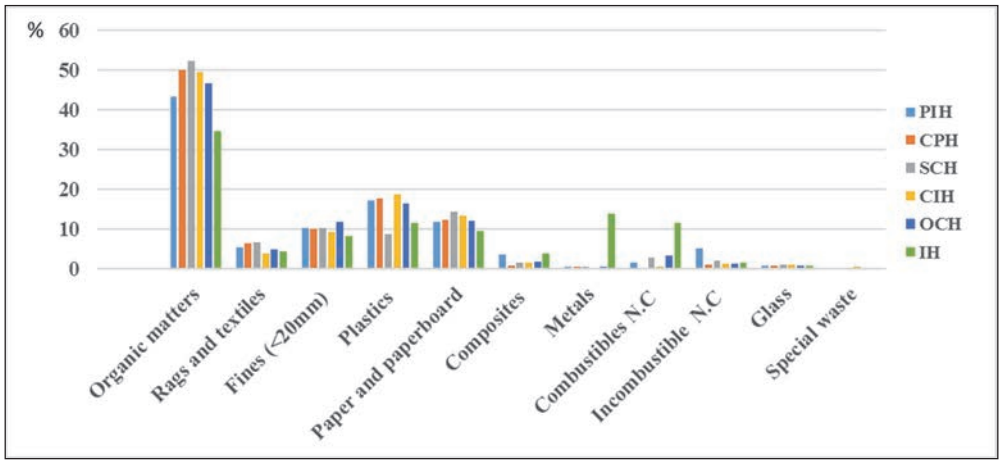


Fig. 4. Variation of the household waste composition by habitat type in autumn 2011

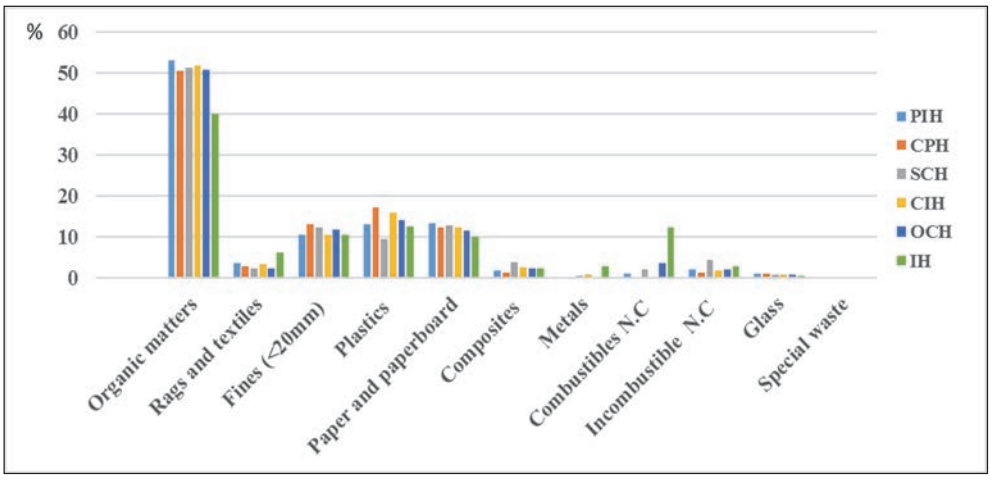


Fig. 5. Variation of the household waste composition by habitat type in winter 2011

The second group contains the weakest components in percentages where the fraction of composite is of 2.25%, and the fraction of incombustible N.C with 3.49%, the fraction of metals comes after by 2.09%, the fraction of glasses by 0.85%. The fraction of the combustibles N.C is of 2.74% on average. However, it should be noted that much of this fraction comes from the illicit habitat during summer and autumn, where the percentage of this fraction is significant (Figs. 3 and 4). This is due to the specificity of this habitat type, which is built on forest land in the west of the city. As in most Algerian cities, this habitat type is built on agricultural land considered by the regulations as strictly prohibited places to build on (Fig. 1, *Photograph n° 5*). Finally, the fraction of special waste (0.22%) comes in the last rank. The average composition of household waste in Annaba was obtained from the average composition of each type of habitat during the study; the results are presented in Table 6.

3.3. Comparative study

In order to understand household waste evolution with time in Annaba city, we did a comparative study between our results, those obtained in 2001, those of the country, of the capital and those of some developed countries. The analysis of the results in (Table 7) shows that the composition of household waste of the city has partially varied, particularly the organic matter which decreased by -22.48% in 2011 compared to 2001, and of -26.28% compared to the national level. It is the same case also in the capital (Algiers) with -18% compared to the national level, this reduction reflects the mode of household consumption which become based on the consumption of products preserved and packaged, which led to the reduction of organic fraction in favour of the remaining fractions especially the fractions of plastic and cardboard. Paper and paperboard were decreased by -7.4% in 2011 compared to 2001 and of -4.1% compared to the national level and this due to the existence of an informal activity of paper and paperboard recovery in the city.

Annaba city is characterized by a plastic average percentage of (10.01%) which is close from the national average (10%) and that of industrialized countries (11.8%), because the plastic remains the most widespread way for the packing of drinks and the household's need and this is why it is not the subject of a significant change from the type of habitat to another.

Table 6. Household waste compositions by type of habitat (%)

Four seasons (year)							
Categories	***P I H***	***CPH***	***SC H***	***C IH***	***OCH***	***I H***	***Average composition***
Organic matters	43.07	49.26	51.58	49.53	46.67	34.18	45.72
Paper and paperboard	5.32	6.37	6.40	3.85	4.99	4.26	5.20
Plastics	10.53	10.09	10.17	9.21	11.92	8.12	10.01
Rags and textiles	17.16	17.67	8.50	18.77	16.41	11.74	15.04
Fines (<20mm)	11.80	13.03	14.25	13.29	12.14	9.64	12.36
Composites	3.75	0.82	1.73	1.66	1.75	3.77	2.25
Combustibles N.C	0.44	0.50	0.49	0.38	0.45	14.18	2.74
Incombustible N.C	1.65	0.19	3.60	0.59	3.36	11.55	3.49
Metals	5.25	1.10	2.06	1.16	1.32	1.63	2.09
Glass	0.89	0.72	0.98	1.04	0.75	0.74	0.85
Special waste	0.12	0.16	0.20	0.48	0.20	0.15	0.22
Total	100	100	100	100	100	100	100

Table 7. Household waste compositions in some cities (%)

Country	***City***	***Organic matter***	***Paper and paperboard***	***Plastics***	***Metals***	***Glass***	***References***
Algeria	Algeria	72	9.3	10	3.2	1.36	AND (2014)
	Algiers	54	13.4	16.45	1.67	1.68	AND (2014)
	Annaba	68.2	12.6	11.2	3.7	1.1	Guermoud et al. (2009)
	Annaba	45.72	5.20	10.01	2.09	0.85	This study
France	Paris	28.8	25.3	11.1	4.1	13.1	Aina (2006)
Italy	Palermo	31.7	23.1	11.8	2.7	8.3	Mastro and Mistretta (2004)

The metals (2.09%) are also close to the national average (3.2%) and not far from that of industrialized countries (4.1%). In more glass percentage in Annaba city is close to that of the capital and the country; however, industrialized countries generate more glass than developing countries. This is due to nutritional practices and the tendency towards a unification of the quantity rejected (Guermoud et al., 2009).

4. Conclusions

In Algeria, with the apparition of new consumption pattern; the evolution of the household waste composition varies faster than the actions led by the state. Also; in Algerian city the quantitative and qualitative data concerning household waste are generally national and not updated; which is a real handicap to choose an adequate waste management method, for this; this study allowed a data update relative to the generation and the physical composition of household waste thrown by habitat type in Annaba city.

This study showed that the quantity and the generated composition of household waste are a function of the seasons and type of habitat, even more; this study shows that this habitat type represents a hierarchy of standard of living in Algeria cities.

Compared to those obtained on 2001, the results of this study confirm the reality that organic matter proportion has significantly decreased (45.72% in 2011), as a result of the new consumption pattern; so, composting persists the first segment of a solution for the household waste management in Algerian cities.

Nevertheless, a recovery system for some components (plastic, paper and paperboard, metal, glass) seems interesting as the second segment of a solution for a rational system of waste management.

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